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Global Effort for Polio Eradication : India on the Verge of Being Declared Polio Free

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India is now on the verge of achieving an unprecedented milestone of being a polio free nation for two full years. The last lone known case of wild polio, with the onset of paralysis, detected in India was in the year 2011 in a two year old girl in Panchla block of Howrah, on 13th January 2011[1] and ever since India has

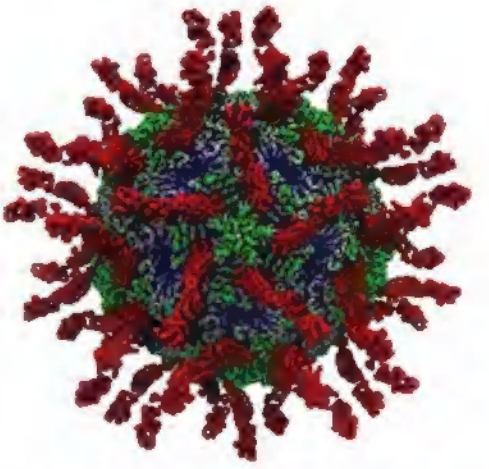
Two year old Rukhsar Khatoon with her mother.

been a polio free nation. If India continues to maintain its current record for another year, it would be permanently declared as a polio free country by the World Health Organisation (WHO). This outstanding achievement is seen as the result of persistent and focused effort and unprecedented collaboration among scientists, administrators and international partners. Polio eradication campaign in India has combined cutting edge research on vaccines with an extensive implementation scheme and an intensive monitoring - cum-follow up plan. The scheme has covered every nook and corner of this vast and diverse country and is backed up by effective campaigning by public and private agencies, a strong political desire and relentless surveillance. The programme has received the highest level of social and political commitment which is reflected in the resource allocation and the continuous ground level actions to identify and reach out to the most vulnerable children while ensuring maximum reach and optimum use of available vaccines under the guidance of top national and international experts.

This article focuses on the fascinating history and development of the polio vaccine and chronicles the struggles that went behind this largest public health initiative in history - Global Eradication of Polio. It gives an insight into the global efforts to eradicate polio against great odds with special emphasis on India.

What is Polio

The word *poliomyelitis* (Paralytic poliomyelitis), meaning, Polio in short, the medical term used to describe the effect of poliovirus (PV) on the spinal cord, is derived from the Greek roots for gray (polio) and marrow (*myelon*). It describes the tissue most commonly affected in the spinal cord that leads to the symptomatic manifestation of paralysis[2]. Polio is a faeco orally transmitted disease caused by an intestinal virus that may attack nerve cells of the brain and spinal cord. Research in medical diagnostics, biomedical research, understanding the genome etc, especially in the later part of the twentieth century, including the Human Genome[3,4] has helped the human society in the development of vaccines which have helped us in combating this deadly pathogen. The genome of polio virus is comparatively small yet it is packed with requisite information to make it a formidable pathogen[5].



Electron Microscopy Image of the Poliovirus.

Poliovirus, a member of the enterovirus subgroup are

the transient inhabitants of the gastrointestinal tract, are stable at acid pH and have an RNA genome, which is 7411 nucleotides long[6]. There are three poliovirus serotypes (P1, P2, and P3) and there is minimal heterotypic immunity between the three serotypes. It can rapidly be inactivated by heat, formaldehyde, chlorine and ultraviolet light.

Polio can be spread through contact with contaminated feces or through airborne droplets in food or in water. The virus enters the body through nose or mouth, and then travels to the intestines where it incubates. Next, it enters the bloodstream where anti-polio antibodies are produced. In most cases, this stops the progression of the virus and the individual gains permanent immunity against the disease[7]. Polio manifests in three ways; mild polio, non paralytic polio and paralytic polio. The symptoms of Polio include fever, headache, sore throat, and vomiting. Some of the Polio victims develop neurological complications, including stiffness of the neck and back, weak muscles, pain in the joints, and paralysis of one or more limbs or respiratory muscles. In severe cases Polio may prove to be fatal as a result of respiratory paralysis.

Polio was feared for it was wrongly perceived that anyone who contracts the polio virus is certain to be paralyzed and may even die. This is contrary to facts and in most infections caused by polio there are few distinctive symptoms of Acute Flaccid Poliomyelitis, AFP in short. In fact, 95 percent of everyone who is exposed to the natural polio virus won't exhibit any symptoms, even under epidemic conditions since the human immune system is capable of protecting us from this pathogen[8]. Only about 5 percent of infected people will experience mild symptoms, such as a sore throat, stiff neck, headache, and fever, often diagnosed as a cold or flu. Muscular paralysis has been estimated to occur in about one in every 1,000 people who contracts the disease[9].

Early accounts of Polio

One of the earliest written accounts of Polio is that of the Pharaoh, Siptah, who ruled ancient Egypt from 1200 BC to 1193 BC. It is said that Siptah was stricken with paralysis disease as a young boy. There is also a myth associated with the incident. However the oldest identifiable reference to the prevalence of Polio once again comes from Egypt in the form of an Egyptian Steele, a stone engraving about 3000 years old, which describes a priest with a withered leg, suggesting that

Egyptian Steele, a stone engraving about 3000 years old.

polio existed for thousands of years[10]. Many references to Polio also appear in the Bible in which polio is translated as palsy. In English language translation of the Bible, the word palsy is used instead of the word "*paralysis*", which is derived from the French word *paralesis*, meaning paralysis. This was shortened to *palesie*, which appeared as palsy in the King James Version of the Bible in the 16th century.

Sir Walter Scott.

Sir Walter Scott (1771-1832), a Scottish novelist and

poet, wrote about his own case of Polio[11]. However it was only in the year 1789 that a proper description was given for this disease by the British physician Dr. Michael Underwood. He was the first person to give the first known clinical description for polio which he called the *"debility of the lower extremities"* [12]. He further stated that polio disease was responsible for the hindrance of the lower extremities in children that was recognizable as poliomyelitis.

Dr. Jacob Von Heine, an orthopedist from Germany was the first person to conduct systematic investigation of polio. He developed the theory that this disease may be contagious. He published a 78 page monograph in 1840 which describes the clinical features of Polio and also the symptoms associated with it. Dr. Heine further suggested the involvement of the spinal cord associated with this disease. Unfortunately due to the limited medical knowledge of that time and also because of the sub microscopic nature of the polio virus Heine and others could not understand the contagious nature of the disease. Based on his study the illness associated with Polio was recognized as a clinical entity. It is in recognition of this that Poliomyelitis is often referred to as *Heine-Medin* disease, after the works of Heine and Karl Oskar Medin.

During the 1905 polio epidemic in Sweden, Dr. Ivar Wickman, Swedish pediatrician, was the first to clearly show the infectious nature of polio. In the year 1907, Wickman also categorized the three different clinical types of Polio namely poliovirus serotypes P1, P2, and P3. This was soon followed by the isolation of the poliovirus in laboratory monkeys in 1908 by Karl Landsteiner, Viennese immunologist, who was awarded the Nobel Prize in Physiology and Medicine in 1930 for his discovery of the human blood groups[13], and his associate Evvin Popper in Vienna. They also discovered that bacteria could not be found in spinal cord tissues of infected human and they therefore thought that perhaps bacteria were not the causes for the disease. This led them to suggest that virus was the causative agent of Polio. They further experimented by injecting suspensions from the spinal cord of a diseased 9-year-old boy into rabbits, guinea pigs, mice and monkeys. Only the monkeys showed signs of disease. They ground up the spinal cords of children who died of polio and injected the material into monkeys. Soon the monkeys developed the disease. They also observed that no bacteria were found in the monkeys and their nervous system changes resembled those of rabies. Based on their findings, Landsteiner suggested that the disease has a viral etiology. He then sent fragments of a spinal cord from a 13-year-old child afflicted with poliomyelitis to the Pasteur Institute in Paris. Poliovirus was shown to be a filterable virus that could spread along nerves and be transferred between monkeys.

The discovery of the virus-causing poliomyelitis was immediately accepted. In the following years Simon Flexner and Paul Lewin working at the John Hopkins University in Maryland, confirmed Landsteiner and Poppers findings[14]. This was of great importance since scientists could now attempt to find a vaccine to stop the spread of this disease. By 1909-10, the main focus of polio research had shifted to the Rockefeller Institute for Medical Research in New York City. The polio research at the institute was lead by Dr. Simon Flexner and his team. Indeed, 1910 was a landmark year for polio; the Congress of American Physicians and Surgeons devoted more attention to polio that year than to any other subject. In Flexner's lab the poliovirus seemed to only infect the nervous system, but was also present in a small number of non-neural sites, particularly the upper nasal area after direct inoculation. Polio thus seemed to be a respiratory infection with the virus spread by infected droplets followed by direct nervous system invasion via the nerves in the nose. This nasal-nervous system model dominated how polio was approached until the late 1930s.

During the next course of the research one of the first questions to be answered was whether just one particular virus caused polio or if there was more than one kind of virus and how this was transmitted. Research on this question took several years. But it was finally proved there are just three strains or types of virus that cause the ailment. This gave hope that a vaccine could be produced to prevent polio. Sabin was the first researcher to show that polio virus was present in digestive system as well as brain and spinal cord.

The study and understanding of how polio was transmitted from one person to another was the next important step towards better understanding of the

spread of this disease for a possible vaccine. Flexner and Lewis during their initial study of this disease were of the opinion that polio was spread directly from the nose to the brain. They introduced washing from nose and throat of the infected people into the monkey's nasal passages. Monkeys developed polio so they concluded that this was the mode of transmission. This however was not the case. Unfortunately for the next 20 years or so people believed that this was the way by which polio was transmitted.

A hint to the true means of transmission of this disease was found in 1912 when Swedish researchers discovered polio virus in the contents and walls of the human small intestine. It was not until 1941 that Albert Sabin showed that polio virus was not present in the nasal membrane of patients who died of polio. He demonstrated the presence of the virus in the digestive tract as well as brain and spinal cord.

Polio struck fast and there was no known cure for this crippler disease and no one was spared of this dreaded disease, not even the rich and powerful, including the then President of USA Roosevelt. Polio crippled its victims for life. The scene of people hobbling on crutches, rolling in wheelchairs, or lying immobile in giant iron lungs, across the globe was one of the most common scenarios and the number of people who suffered from this disease increased every year. No one knew for sure the exact mechanism of polio's transmission and therefore it was very common then to place many areas under strict quarantine when cases of the disease began to manifest themselves. Only the fear surrounding AIDS now can rival the feelings people had about polio in the first half of the twentieth century.

Polio Eradication

The first reported outbreaks of polio in Europe were reported in the early 19th century, and outbreaks were reported in the United States a few years later. For the next hundred years, epidemics of polio were reported from developed countries in the northern hemisphere each summer and fall. These epidemics became increasingly severe, and the average age of persons affected rose, which increased both the disease severity and number of deaths from polio. Polio reached a peak in the United States in 1952, with over 20,000 paralytic cases. However the polio incidence fell rapidly following introduction of effective vaccines. The last case of wild-virus polio acquired in the United States was in 1979.

Only once in human history have we witnessed the total eradication of a dreaded disease, and that was smallpox more than two decades ago. The humanity now stands on the brink of a second major triumph to rid the society of Polio which has been achieved through the "global eradication of polio" campaign spearheaded by the WHO with support from Rotary International and several other governmental and non governmental agencies. As we are inching very close to this remarkable milestone it is time to look back on some historically significant developments that have led us to this remarkable collective human endeavor.

Franklin D Roosevelt.

Franklin D Roosevelt, President of the United States from 1932 to 1945, a polio victim, popularly known as FDR, declared a War on Polio during his presidency tenure. He constructively used the tremendous resources of postwar America to combat the polio menace and aided the scientific community to develop a vaccine that could help prevent polio. Roosevelt wore heavy steel braces on his legs and walking was difficult for him. Most of his time was spent in a wheelchair. Roosevelt contracted the poliomyelitis paralysis on Aug 10, 1921 at the age of 39 years while vacationing at his Canadian summerhouse on Campobello Island, during one of his swimming outings.

Warm Springs is the most famous of Georgia's seven known warm springs and the water at the warm spring is believed to contain some magic therapeutic properties because of the presence of some beneficial mineral in its waters. The native Indian habitants believed that the water at the Georgia Springs could be beneficial as a medical cure for several diseases. It was believed that the warm water springs contained minerals and that the constituents of these minerals in the water at the spring could treat various diseases. For the local Indians, the springs were probably a place of healing where the Indians of all tribes were allowed to bring their sick and wounded to drink the waters and bathe in the mud[15].

Recognizing the potential of the location as a great tourist resort, in the year 1923 Warm Springs Company was formed with George Foster Peabody as its president. One of beneficiaries of the magic healing properties of the warm springs of Georgia was a young civil engineer from New York, Louis W. Joseph. He had been greatly helped by swimming in the pool at Warm Springs. On learning about this incident and about the benefit that the warm springs could provide to polio victims, Peabody, who had befriended Roosevelt when FDR had been Secretary of the Navy and an unsuccessful vice-presidential candidate, informed Roosevelt about the incident and asked Roosevelt to try if this could help him. Roosevelt came to Georgia in 1924 and discovered that a swim at the warm springs served as a hydrotherapy and he was able to easily move his lame legs under water. Roosevelt remained closely tied to the Georgia springs for the next 21 years, until his death in 1945[16].

A local news paper published an article that Georgia's Warm springs have provided therapeutic relief to Roosevelt, who by then was already very famous. This local news article was soon picked up and reprinted nationally. Soon thereafter other polio victims began to arrive at the old resort for treatment and stayed in the adjacent cottages. The polio activities overshadowed the vacation resort uses for which the company was formed and therefore, on the insistence of Roosevelt, Warm Springs Foundation was established in 1925 for the study and after-treatment of infantile paralysis (polio). Roosevelt became the head of the foundation and Peabody one of the four trustees. The new Foundation had two objectives namely to use the natural facilities of Warm Springs and the skill of an able, carefully-selected professional staff for the direct aid of patients and to pass on to the medical profession and to hospitals throughout the land, useful observations or special methods of proved merit resulting from this specialized work, which might be applied elsewhere.

Unfortunately, notwithstanding the noble cause of the Foundation, it received protests from regular resort guests who felt their sharing of the facilities with the patients of Polio would endanger them to the disease. During this period there was lot of confusion and misunderstanding about polio. In order to allay the fears of the regular guests, Roosevelt, on his own, built a small treatment pool a distance from the public pool, for the exclusive use of the polio patients.

Roosevelt, in the year 1926, invited Dr. LeRoy W. Hubbard, an orthopedic surgeon of the New York

Little White House.

State Health Department, to conduct a medical study on the effects of warm water on polio victims. Dr. Hubbard observed 23 patients for a period of time and then wrote a detailed report indicating that each patient had seemed to improve, and some showed marked improvement. This convinced Roosevelt of the benefits for treating polio and "swimming his way to health." As Peabody once said, "Without Warm Springs, Franklin Roosevelt could never have become the President." Roosevelt even after becoming the President of the United States continued to visit the warm springs. The cottage where he stayed during his visit became the "Little White House."

The Georgia Warm Springs Foundation dedicated itself to the conquest of polio. Through its fund raising "President's Birthday Balls" and the "March of Dimes" treatment was provided to polio victims. When the Salk and Sabin polio vaccines virtually eliminated polio, the need for the Foundation was greatly lessened. The Little White House and other properties were willed to the Foundation by President Roosevelt. In 1947, a memorial was dedicated to him at the site, and has been visited by millions of people.

'President's Birthday Balls' poster.

In 1932, Roosevelt was elected President. The fact that the disease had affected a man in the White House seemed to arouse public's interest. The trustees of the Georgia Warm Springs Foundation decided money could be raised for the foundation by holding dances in cities across the nation on the President's birthday, January 30. More money was raised than was needed for Warm Springs, so it was used for scientific research. In January 1938, alarmed by decades of worsening polio epidemics and the terrible toll the virus was taking on America's young, President Roosevelt established the National Foundation for Infantile Paralysis. The Foundation emphasized the nationwide significance and non-partisan character of the polio crusade. Roosevelt believed that people could solve any problem if they worked together. Comedian Eddie Cantor coined the phrase "March of Dimes" (playing on the popular newsreel feature "The March of Time"),

The March of Dimes - polio eradication campaign.

appealing to radio listeners all over the country to send their dimes directly to the White House. The campaign to start with received lukewarm response but within weeks of launching the campaign it became immensely popular and White House was flooded with loads of Dimes thus proving to be hugely successful. The National Foundation officially changed its name to the March of Dimes in 1979[17].The money collected from this campaign was put to proper use by financing medical research in the leading universities and medical schools to develop a polio vaccine. This research has led, step by step, to the ultimate victory over polio. The March of Dimes occupies a unique place in American history. Its efforts to provide care for the victims of polio while aggressively working to develop vaccines against it, represents the first large-scale, nationwide biomedical initiative, led by a charitable organization. It also helped make the volunteer movement an integral part of the fabric of American life. March of Dimes investment has also been made in other research fields in science, which include support to 11 Nobel laureate scientists whose original work was supported by grants from March of Dimes.

J.F. Enders, T.H. Weller and F. C. Robbins were jointly awarded the Nobel Prize.

Early efforts in the development Polio Vaccines

The first great hope of developing polio vaccine emerged in 1934-35. Dr. Marice Brodie developed an inactivated polio vaccine and it was soon followed by the rival group headed by Dr. John Kolmer who developed an attenuated version of the polio vaccine. The success though was short-lived. Their hasty uses of vaccines in parts of US proved ineffective and in several cases were fatal. This experience left polio researchers hesitant to attempt another polio vaccine for the next 20 years.

An important new era in the history of polio vaccines began when a short paper was published in the journal Science by J.F. Enders, T.H. Weller and F.C. Robbins, of Boston Children's Hospital and Harvard Medical School. They were jointly awarded the Nobel Prize in Physiology or Medicine in 1954 *"for their discovery of the ability of poliomyelitis viruses to grow in cultures of various types of tissue*[18] *"*.

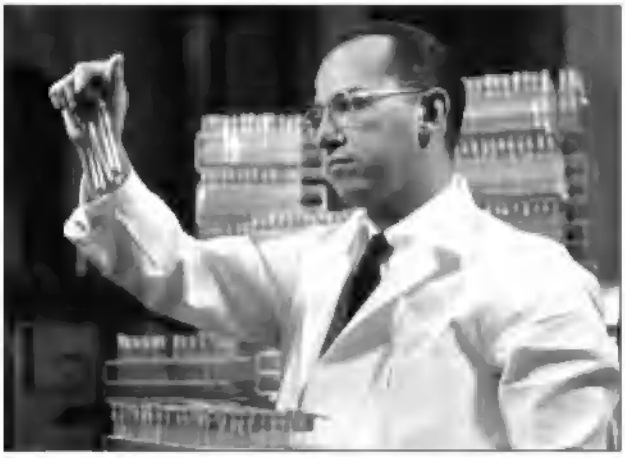
Their paper described the means of solving the long-standing problem of culturing the poliovirus in test tubes using non-nervous tissues. The essence of their discovery is described in their Nobel Prize acceptance speech[19]. Their discovery finally provided a method to cultivate poliovirus in vitro. This landmark discovery finally opened the door for the development of a practical polio vaccine.

In 1951 a method of providing passive immunity to polio was first tried in North America. During the course of this experimentation it was discovered that the small amounts of virus that entered the bloodstream could be overcome by a small amount of poliovirus antibodies. Poliovirus antibodies contained in gamma globulin could thus be used to neutralize poliovirus infection over a limited period of time. Further studies showed antibodies against polio are formed in the blood of the victim. That's why a person who has suffered an attack by one strain of virus is immune to that strain thereafter. Subsequent works made it apparent that a practical vaccine for the prevention of polio could be produced.

Dr. Jonas Salk was born to the Russian–Jewish parents, and attended the medical school in New York University. He spent a year researching the recently discovered influenza virus. His technique succeeded and influenced his later work on polio: He later said "The principal that I tried to establish was really that it was not necessary to run the risk of infection, which would have been the case if one were to try to develop an attenuated or weakened poliovirus vaccine. And so it seemed to me the safer and more certain way to

proceed. That if we could inactivate the virus that we could move on to a vaccine very quickly.[20]

Dr. Salk while working at the University of Pittsburgh undertook a major effort to sort out 196 known strains of poliovirus into three immunologically distinct types and categorized them as strains I (161 strains), II (20 strains) and III (15 strains). In 1946 he became assistant professor of epidemiology at Michigan. By 1951, based



Jonas Salk was the first to develop a successful polio vaccine.

on his earlier work of developing an inactivated influenza vaccine, and his experience with the poliovirus type project, coupled with the work of others studying poliovirus immunity in monkeys, Salk suggested that an inactivated polio vaccine might stimulate active immunity in humans. He developed the polio vaccine by cultivating three strains of the poliovirus separately in monkey tissue.

The virus was separated from the tissue, stored for a week, and killed with formaldehyde. He then conducted tests to make sure that the virus was dead. He proved that a series of three or four injections with the killed virus vaccine were required to confer polio immunity. The works of Dr. Andrew J. Rhodes, a leading virologist from England with a special interest in polio, were of special significance to Salk in the development of his vaccine. By 1951, Rhodes' research team was able to grow all three types of poliovirus in a variety of tissues. Salk used the method of growing poliovirus in different tissues in the development of a polio vaccine. This vaccine came to be known as the Salk vaccine. Salk tried his vaccine by first injecting himself and his family to infuse a sense of confidence among the public. He then proceeded to administer the vaccine to residents of an institution for disabled children near Pittsburgh[21]. The encouraging results of the trial were published in March 1953. It was around this time that Dr. Leone Farrell developed the "Toronto technique" to produce bulk quantities of poliovirus fluids in large bottles. This development paved the way for mass production of Salk vaccines.

Encouraged by Salk's results, in July 1953 the National Foundation for Infantile Paralysis asked Connaught Medical Research Laboratories (Aventis Pasteur Limited) to provide all the poliovirus fluids required for an unprecedented polio vaccine field trial in the US. Some 3,000 litres of bulk poliovirus fluids produced by Connaught were shipped to two major pharmaceutical companies, Parke Davis and Eli Lilly in the US to be inactivated and processed into a finished vaccine. Before being released for the field trial, each batch of vaccine had to pass through a battery of tests, first by Connaught, then each company, Salk's lab and the US government. Amidst intense publicity, the first children were given the new polio vaccine on April 26, 1954. The field trial was one of the largest medical experiments in history, at that time, and involved an elaborate tracking of some 1,800,000 children in the age group of 5-8 years. They were either given the vaccine, or were simply observed to see if they contracted polio or not. The results were dramatic. Cases of polio fell spectacularly in the vaccinated test groups. In 1955, the government quickly granted permission for the vaccine to be distributed to the children of US. On April 12, 1955, the highly anticipated clinical trial results turned into a major media event, perhaps the biggest in medical history. "SALK'S VACCINE WORKS!" screamed the headlines. Dr. Thomas Francis, director of the trial, reported that the vaccine was 60 to 80 per cent effective against paralytic polio. He and Salk stressed that the vaccine was good, but it was not perfect.

The success though was not long lived. Suddenly, on April 25, 1955, the Salk vaccine euphoria was shattered when the first of a total of 205 cases of polio associated with vaccine made by Cutter Laboratories in California were reported. The problem was traced to incomplete inactivation of some virus particles, which was soon corrected. Since then the vaccine has been highly effective, with a 70 - 90% protection rate. The Salk vaccine is given in two intramuscular injections spaced

one month apart and is to be followed by boosters every 5 years.

Albert Bruce Sabin, born in 1906 in Poland, then a part of Russia, to escape racial persecution, immigrated with his family to the USA in 1921. He graduated from New York University in 1928. In 1935, he joined the staff of Rockefeller University before moving in 1939 to Cincinnati Children's Hospital to conduct research on viruses. His experience of working as a consultant to the army during World War II, during which time he isolated the virus of sand fly fever, and also helped in developing a vaccine against dengue fever, benefitted him in developing a live oral polio vaccine.

Sabin showed that poliovirus first invaded the digestive tract and then the nervous system. In 1957, in an effort to improve upon the Salk vaccine, he began testing a live, oral form of vaccine in which the infectious part of the virus was inactivated (attenuated) and not killed, as was the case in Salk vaccine. He developed a live but attenuated oral vaccine that not only proved to be superior in administration, but also provided longer lasting immunity than the Salk vaccine. The killed-virus vaccine of Salk could protect only against paralysis, whereas Sabin's live attenuated vaccine could guard against both paralysis and infection. Dr. Sabin demonstrated the effectiveness of his vaccine in the field trials during the period 1958 and 1959. After a clash between the rival camps and their principals, by 1962 Salk's vaccine was replaced by the Sabin vaccine[22].

Albert Bruce Sabin improved upon the Salk vaccine and developed a live attenuated oral Polio.

Sabin's, live oral polio vaccine (OPV) for immunization against poliomyelitis, vaccine could be taken orally and it provided longer immunity than the killed-virus vaccine. This vaccine became available for use in 1963. The Sabin oral vaccine is given in 3 doses in the first two years of life, and a booster is given subsequently when the child starts his schooling. Further boosters are not given unless the patient is exposed to polio or travels to an endemic region. The advantages of a live, oral vaccine are its long-lasting immunity, the prevention of re-infection of the digestive tract, and the lower cost of administering the vaccine orally because sterile syringes and needles are not necessary. Sabin's oral polio vaccines are used in India during the National Immunizations Day campaigns.

Sabin's Oral trivalent polio vaccines that are routinely used in Pulse Polio Campaigns in India.

Progress towards eradication of polio

The eradication of the polio with the use of Polio vaccines in the developed nations prompted the World Health Organization, in 1988, to set a goal for itself of eradication of poliomyelitis from the entire world by the year 2000[23]. Although way off the target the world is now poised for this unprecedented achievement. The results speak for themselves. The number of polio cases worldwide has been cut dramatically in just over a decade. In 1988, according to WHO, there were an estimated 350,000 cases[24], of which only 10 per cent were actually reported. Unfortunately the goal of polio eradication by the year 2000 could not be achieved. All but 6 countries - India, Pakistan, Egypt, Afghanistan, Nigeria and Niger, achieved elimination of WPVs by 2000.

By the end of 2001, the number of cases had dropped to 537. Although the number of reported cases increased during 2002, due to polio outbreaks in India and Nigeria, the majority of these cases were concentrated in isolated areas thus giving an optimistic view for a world free of polio[25].

Polio Eradication Efforts in India

India officially committed itself to eradicate polio, supporting the WHO resolution to that effect in the very same year 1988. India had more polio cases than any other country in the world. It was estimated that the Indian health care personnel officially reported to the government over 24,000 cases of polio[26] in reality though, there were probably many more cases that went unreported. The sight of children and adults with withered arms and legs throughout the cities, towns and villages of India was routine, and some of the major risk factors for polio virus transmission like crowding, poverty and poor sanitation were present in India to a degree not seen in most countries.

India was slow to adopt the campaign of polio eradication. Some officials were skeptical of its implementation and argued that there were other more pressing health priorities in India and that the cost of polio eradication campaign would limit resources for providing health services to India's general population. However, India was able to commit to the programme largely due to the influence of Dr. John Andrus, an American from the US Public Health Services who arrived in India in 1993 as Regional Adviser for polio on the WHO/ SEARO (South East Asia Regional Office) staff and Dr. Kaushik Banerjee, Director of India National Immunisation Programme in the Ministry of Family Welfare.

National Immunisation Days have been a common feature of the Indian Polio eradication programme for quite some time now. Each year more than 170 million children, under the age 5, are vaccinated on these days and nearly a billion doses of oral polio vaccines are administered annually. Indian polio eradication campaign, which was an epidemiologic challenge of unprecedented proportion, tells an inspiring story. If the milestone of eradicating India endures, which it most likely will in the next two years, it will be the result of a persistent and focused effort and unprecedented collaboration among scientists, administrators and international collaborators. This campaign has combined cutting edge research on vaccines and door to door follows up, public and private outreach, political desire and relentless surveillance.

Polio eradication programme in India is spear headed by the government of India, along with key partners WHO, UNICEF and Rotary International. The initial combat on polio came with the introduction of universal immunization programme in 1985. Under the Universal Immunization Programme (UIP), more Indian children were provided oral polio vaccine (OPV) than ever before in history.

This campaign now involves more than 2 million volunteers besides the Indian chapters of Rotary International. It reached 87 million children during the National Immunization Days in 1995 & 1996 and in the very next year it reached 125 million.

The number of reported polio cases dropped from over 24,000 in 1988-89 to less than 5,000 in 1993-94. Although this was encouraging, the government of India soon responded to the need to intensify the polio eradication effort and accordingly developed the Pulse Polio Immunization (PPI) strategy. The key innovation in this programme was utilization of mass immunization campaigns to supplement the routine immunization activities. The state of Delhi was the first area to adopt a PPI component in 1994. The first round of National Immunization Day (NID) programme was held in late 1995, which was followed with a second round in early 1996. Children under the age of 5 years were invited to take polio drops. Over 500,000 booths were set up nationally during the first NID programme, and on a single day a total of 87 million children received the vaccine. The scope and intensity of mobilization utilized for this activity has been unprecedented in the annals of the health initiatives in India, and possibly, the world.

Children celebrating one complete year of Polio free India.

To understand this remarkable achievement, it is important to comprehend the scale of the efforts made to meet this gigantic challenge. At the same time as the NIDs were being initiated, it became clear to the government that better information on polio cases was necessary to complete the job of polio eradication. The government of India and the WHO developed a collaborative unit, the National Polio Surveillance Project (NPSP)[27] to provide accurate and rapid surveillance information on polio cases in India. There is now a systematic tracking of cases finding the source of the infection and flooding infected area with massive doses of polio vaccines. Beginning in 1997, NPSP has supported over 300 surveillance medical officers throughout India to coordinate polio surveillance activities. In addition to NPSP network, a regional laboratory network of 9 highly qualified Indian research centres provides rapid and accurate analysis of samples from patients.

Polio vaccination in a train.

Polio cases came down to 265 in the year 2000 and in the backward state of Orissa it came down from 45 to Nil. In the year 2002 polio bounced back and 1600 cases were reported. The number of cases of polio in the year 2005 was 66 and during the years 2006 to 2009 they ranged from 550 to 874. Once again the year 2010 was very effective and polio cases came down to just 43 cases. Last recorded case of wild polio virus infection was in Jan 2011.

The major players in the global polio eradication initiative (GPEI) include the WHO, CDC, UNICEF and Rotary International and private donors like the Gates Foundation. India accounts for 32% of financial requirements for the GPEI. India has financed a cumulative total of 1 Billion US $ for polio eradication between 2003 and 2010[28]. India will be spending 79% of the campaign cost between 2011 and 2013. International funding has supported social mobilization. Gates Foundation is the largest donor and other agencies include WHO, UNICEF, DANIDA and Rotary International.

The success story of Indian polio eradication programme and the vigilance that we should continue to keep on the wild polio virus can best be summed up in the words of the Union Health Minister, Shri Ghulam Nabi Azad, who, while announcing the completion of one full polio free year on 13 Jan 2012, said "We are excited and hopeful, at the same time, vigilant and alert" and cautioned, "there is still no room for complacency and we need to ensure no case of polio infection for three consecutive years for India to celebrate eradication of poliomyelitis".

Polio vaccination in rural India.

Conclusion

Heading towards the third consecutive year of freedom from wild polio, India has developed an end game strategy for ensuring a polio free world with support from WHO and other partners. It has taken a carefully planned strategy of a phased withdrawal of the oral polio vaccines from the mass immunization programmes and phasing in the use of inactivated polio vaccine (IPV) to complete the eradication process and containment of all wild, vaccine-related and Sabin polioviruses. It is also necessary for India to guard against the risk of polio resurgence through a distant or cross-border importation of the wild poliovirus especially from our neighboring countries like Pakistan

and Afghanistan, where the virus continues to circulate. The experience gained from this project and the polio infrastructure and expertise developed in the process will be immensely beneficial in strengthening the routine immunization programmes in India for protecting our children from various vaccine - preventable diseases, as well as for overall strengthening of the existing public health systems by applying the lessons learnt during the course of polio eradication.

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